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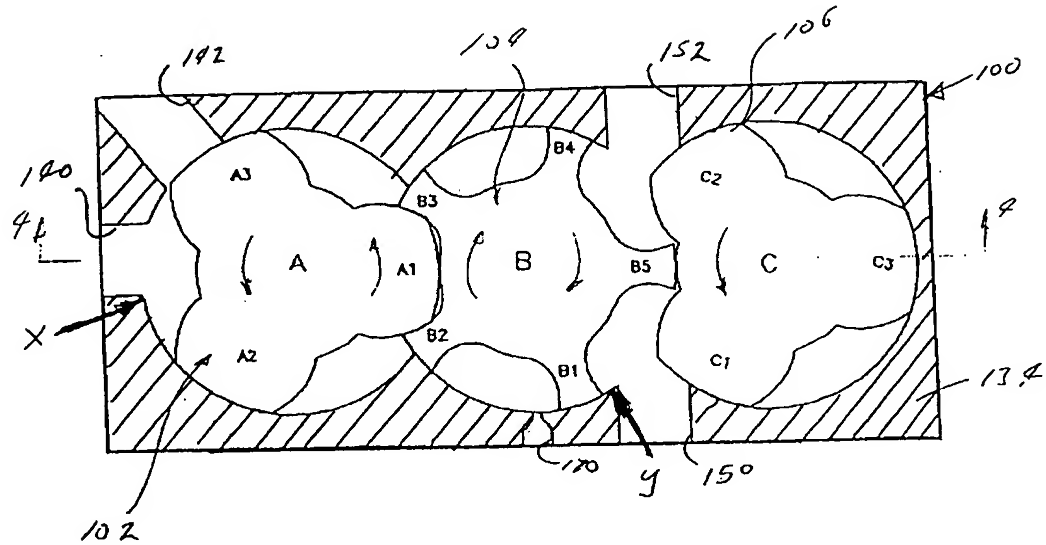
(30) 1997/12/24 (08/997,821) US

(54) **MOTEUR ROTATIF**
(54) **ROTARY ENGINE**



(57) Disclosed is a three rotor engine of the intermeshing lobe and groove type wherein the rotors are transversely aligned and sealingly cooperate with a casing to provide a power rotor, an abutment rotor and a scavenging rotor. The scavenging rotor provides for a positive formation of an air which forces exhaust gases out a primary exhaust port and also aids in air intake through a primary air intake port by expanding the chamber defined between adjacent lobes which provides for the formation of a positive air charge in the chamber for use in the combustion engine. The scavenging rotor helps in reducing unburnt fuel emissions in the exhaust as it provides a charge of fresh air into the exhaust from the abutment or middle rotor to allow complete combustion of any fuel still remaining unburnt in such exhaust.

ROTARY ENGINE

Field of the Invention

The invention relates to a rotary engine and more particularly relates to the type of rotary engine having intermeshing lobes and recesses between a power rotor and adjacent, abutting rotors.

Background of the Invention

U.S. patent No. 3,777,723 granted December 11, 1993 to Lundstrom et al generally depicts a rotary engine of the type having two rotors with intermeshing lobes and recesses. FIGURES 1 and 2 of U.S. patent 3,777,723 are reproduced as FIGURES 1 and 2. FIGURE 1 herein shows a transverse, plan sectional view of the engine along line 1 - 1 in FIGURE 2 whereas FIGURE 2 shows an elevational sectional view along line 2 - 2 of FIGURE 1.

The Lundstrom et al engine shown in FIGURE 1 has a casing 20 enclosing a working space 22 composed of two intersecting bores 24, 26 having parallel axes and intersecting along two straight axial lines 28, 30. The working space 22 has end walls 32, 34 (FIGURE 2) and barrel walls 36, 38 (FIGURE 1) surrounding the bores 24, 26. The casing 20 is provided with inlet channels 40, 42, 44, 46 (FIGURE 2) with scavenging outlet channels 48, 50, with exhaust ports 49, 51 in the barrel walls 32, 34 and further provided with a fuel injection inlet or nozzle 52. A power rotor 54 is mounted in the casing 20 for sealing cooperation with the walls 32, 36 of bore 24. A rotary abutment member, or abutment rotor 56 is mounted in casing 20 for sealing cooperation with the walls 34, 38 of the bore 26 and with the power rotor 54.

Abutment member 56 is provided with five grooves or recesses 60 and intervening lands 58 disposed inside the pitch circle of the abutment member 56, which circle practically coincides with the circumscribing circle of the abutment member. Each groove or recess 60 is provided with two generally concave flanks 62, 64 (FIGURE 1) separated by a generally part cylindrical bottom portion 66. Each abutment member land 58 is further provided with a part cylindrical tip portion 68 connecting the edges 70, 72 of the flanks 62, 64

thereof. A part spherical cavity 74 is provided centrally in the bottom portion 66 of each groove 60 which cavity is unrestrictedly open and extends up into the adjacent flanks 62, 64 towards the groove 60.

The power rotor 54 is provided with three lobes, or lands 76 and intervening grooves or interspaces 78 disposed outside the pitch circle of the power rotor 54, which circle practically coincides with the bottom circle of the rotor. Each lobe 76 is provided with two convex flanks 80, 82 separated by a generally part cylindrical tip portion 84. Each interspace 78 of power rotor 54 is further provided with a part cylindrical bottom portion 86 connecting the roots of the flanks 78, 80 thereof. Each flank 80, 82 of each rotor land 76 follows in a transverse plane a curve of generally epicycloidal type generated by the cooperating edge portion 70, 72 of the abutment member flanks 62, 64. The flanks 62, 64 and the bottom portion 66 of the abutment member 56, in a transverse plane, follow with a free running clearance therebetween, the envelope developed by the meshing lobe 76 of the power rotor 54 as the lobe 76 moves into and out of the groove 60 of the abutment member as the power rotor 54 and the abutment member 56 rotate. The power rotor 54 is provided with a power shaft 88 extending outside the casing 20. Furthermore, the power rotor 54 and the abutment member 56 are interconnected by a pair of intermeshing synchronizing gears 90, 92 as shown in FIGURE 2.

Briefly in operation, fresh air enters through channels 40, 42, 44, 46 (FIGURE 2). Air trapped within the casing and interspaces 60, 78 of respective rotors 56, 54 are brought into communication (FIGURE 1) and compression of the air commences and fuel is injected through injector 52. When the air/fuel mixture is compressed by the cooperation of the lobe of rotor 54 within an interspace, the groove 60 of rotor 56, ignition by a spark plug or the like ignites the fuel and combustion and expansion of gases takes place. Gases after combustion are exhausted through ports 49 and 51. Ports 48, 50 are scavenger outlets permitting fresh air to scavenge combustion gases not otherwise exhausted through ports 49, 51.

Further details of the operation of the Lundstrom et al engine may be secured from a review of the abovenoted U.S. patent, incorporated herein by

reference for such other details.

Notwithstanding the apparent effectiveness of this engine, it suffers from lack of adequate scavenging of exhaust gases which detracts from the efficiency of the engine. Further, there is a tendency for unburnt fuel in the exhaust to be emitted to the air. It would be advantageous therefore to provide a rotor engine of the Lundstrom et al type which has enhanced scavenging of exhaust gases and reduces emissions by providing a charge of fresh air into the exhaust to allow more complete combustion of any fuel remaining unburnt in the exhaust.

Summary of the Invention

Accordingly I provide an engine of the rotary type wherein there is a further rotor sealingly operating within a chamber and cooperating with the rotor designated as the abutment rotor in the Lundstrom et al patent (56), which third rotor is appropriately geared to the other rotors. In a preferred embodiment, this third rotor is configured the same as the power rotor 54 of the Lundstrom et al patent.

More particularly, I provide a three rotor engine of the intermeshing lobe and groove type wherein the rotors are transversely aligned and sealingly cooperate with a casing to provide a power rotor, an abutment rotor and a scavenging rotor. In a preferred embodiment, the abutment and power rotors are similar to rotors 54 and 56 of Lundstrom et al. Whereas Lundstrom has air intake 44, 46 and scavenging outlet channel 50, to scavenge exhaust from the grooves or recesses 60 of the rotor 56, I provide a third rotor which provides for a positive formation of an air which forces exhaust gases out a primary exhaust port and also aids in air intake through a primary air intake port by expanding the chamber defined between adjacent lobes which provides for the positive formation of an air charge in the chamber for use in the engine.

Further, the additional or third rotor, my scavenging rotor, helps in reducing unburnt fuel emissions in the exhaust as it provides a charge of fresh air into the exhaust from the abutment or middle rotor to allow complete combustion of any fuel still remaining unburnt in such exhaust.

The invention in one broad aspect pertains to an internal combustion engine of the type having first and second intermeshing lobed rotors, the first and second rotors each having a plurality of lobes and grooves, the lobes of one rotor intermeshing with the grooves of the other rotor and the intermeshing of the rotors being controlled by intermeshing first and second gears connected respectively to each rotor. The improvement comprises providing a third loped rotor, the third rotor having a plurality of lobes and grooves and being mounted so that the lobes and grooves thereof intermesh with lobes and grooves of the second rotor in a gear controlled relationship. The third rotor cooperates with the second rotor to form a positive air charge which is carried by the second rotor to combustion and to form a positive air charge which is carried by the third rotor to an exhaust port associated with the second rotor.

In one preferred embodiment, the first and third rotors have the same number of lobes and grooves such as 3 and the second rotor has 5 lobes and rotors. In another preferred embodiment, the first, second and third rotors have 3, 4, and 2 lobes respectively.

Brief Description of the Drawings

FIGURE 1 is a schematic, sectional plan view of the prior art engine of U.S. patent No. 3,777,723.

FIGURE 2 is a schematic, horizontal sectional view of the prior art engine of FIGURE 1.

FIGURE 3 is a schematic plan sectional view of the engine according to the invention along line 3 - 3 of FIGURE 4.

FIGURE 4 is a schematic sectional view of the engine according to the invention taken along line 4 - 4 of FIGURE 3.

FIGURE 5 is a schematic view of the rotors and associated gears.

FIGURE 6 is a slightly enlarged view of a rotor showing the location for spark plugs.

FIGURE 7 is an upper, end view of the rotor in FIGURE 6 taken in the direction of arrow 7.

FIGURE 8 is a sectional view of one lobe of the rotor shown in

FIGURE 7 showing the spark plug.

FIGURES 9 - 19 are schematic sectional views of the engine similar to FIGURE 3 but showing various stages in the cycle of the engine, with FIGURE 9 being essentially a repeat of FIGURE 3.

FIGURE 20 schematically illustrates an enlarged view of a rotor lobe illustrating a modified location for a fuel injector and a spark plug.

FIGURE 21 is a schematic plan sectional view like FIGURE 3 but showing a modified engine with a variation in the configuration of two of the rotors.

Description of the Preferred Embodiment of the Invention

As noted in the background of the invention, rotary engines of the type having cooperating lobes, lands, grooves or recesses are well known but have only two rotors, a power rotor, (the rotor from which power is taken from the motor) and an abutment rotor.

Turning to FIGURES 3, 4, the engine according to a preferred embodiment of the invention, has engine block 100 enclosing three rotors, a first rotor 102, a second or middle rotor 104 and a third rotor 106. Rotors 102, 104 and 106 are transversely aligned with parallel axes 110, 112 and 114 respectively.

Most of the power is produced by rotor A and the Lundstrom engine takes power out from the shaft connected to rotor A or the first rotor. Although, as will be evident herein, I prefer to take power out of the second rotor 104, power can be taken from anyone of the rotors. Nevertheless, for the purposes of this description, I use the term power rotor to designate the first rotor or rotor 102, abutment rotor for the middle or second rotor 104 and third or scavenging rotor 106.

The first and third rotors 102 and 106, the power rotor and scavenging rotor, each have three lobes and are configured the same, whereas the second, middle or abutment rotor 104 has five lobes. For ease of designation in the operation of the engine, rotors 102, 104 and 106 are designated as rotors A, B and C with each of their lobes designated as A_1, A_2, A_3, B_1, B_2, B_3, B_4, B_5

and C_1, C_2, C_3.

Each rotor 102 (A), 104 (B), 106 (C) is axially secured to respective shafts 116, 188 and 120. Gears 122, 124 and 126 are respectively secured to the shafts, which gears intermesh and cooperate to control the relative speed of the rotors (FIGURES 4 and 5). In the case of three lobed A and C rotors and a five lobed B rotor, rotor B (104) rotates at 3/5th the speed of rotors A (102) and C (100). The three rotors A (102), B (104) and C (106) are designed not to touch one another or the interior of the casing 100 but are controlled in their respective rotational paths by gears 122, 124 and 126. By way of example, in a prototype engine, the gears controlling rotors A and C have a pitch diameter of 4-⅞ inches and 117 teeth whereas rotor B has a pitch diameter of 8½ inches and 195 teeth. The axis or centerline spacing of the gears is 6½ inches.

Engine block 100 has outer side walls 130, 132 and main intermediate block section 134, wall 130 and section 134 housing the rotor and walls 134 and main section 134 housing the gears. Suitable bearings 138 support the shafts 116, 118, 120 within covered bearing inserts 140 which are suitably mounted in apertures 142 in block side walls 130, 132 and are secured by bolts (not shown) to walls 130, 132. Bolts securing walls 130, 132 to block sections 134 are not shown. Further, for the sake of clarity, the walls and block are not shown with cooling ducts or passageways.

Looking at FIGURE 3, engine block 100 has primary air intake port 150, primary exhaust port 152, secondary air intake port 160 and secondary air exhaust port 162. Fuel injection means 170 is located in block 100 and in this embodiment is in the area of rotor 104 (B).

Each lobe of rotor 102 (A), namely A_1, A_2 and A_3 has a bore 180 in which is housed a spark plug device 182. FIGURES 6 and 7 more particularly show the construction of rotor 102 (A) in plan and side views, whereas FIGURE 8 shows an enlarged cross-sectional view of a lobe A of rotor 102 (A).

As is known in the art, the configuration of rotor 102 (A) (and rotor 106 (C)) having a cylindrical outer portion 184 and cylindrical inner portion 186 of a simple radii, whereas the sides 188 of the rotor are an epicyclic curve. Spark plug device 182, shown schematically as comprising an insert 190 containing

spark plug body 192, ceramic insulator 194 and conductive core 196 is detachably secured within bore 180. Appropriate electrical means, not shown, would activate the spark plug device 182 through conductive lead 198. It will be appreciated that the area 200 within lobe A_1 defined between the spark plug 182 and the outer portion 184 of rotor lobe A_1 is designed to provide for an appropriate compression ratio relative to the fuel being used, preferably about a 10:1 ratio.

Cycles

Now turning to the operation of my engine and FIGURES 9 - 19, the cycles of the engine will be described.

Intake

As seen in FIGURE 9, which is a repeat of FIGURE 3, cooperation between rotors B and C creates primary air intake action of the engine through intake port 150.

Chamber 154 defined in part by lobes B_1, B_5 and C_1 increases or grows in size as rotor C turns counterclockwise and rotor B turns clockwise to positively suck in air. As rotation of rotors B and C continues into the position shown in FIGURE 10, chamber 134 splits into two separate volume chambers 154a and 154b. The positive air charge in chamber 154a, defined by rotor lobes B_1 and B_5, is carried around by rotor B (104) and the positive air charge in chamber 154b, defined by rotor C lobes C_1, C_2, is carried around by rotor C (106). Fuel is injected into chamber 154a when chamber 154a rotates past fuel injector 170, as shown in FIGURE 11. Turning to rotor A and progressing from FIGURE 9 to FIGURE 11, air is sucked through secondary air intake port 160 into chamber 164, defined by lobes A_2 and A_3 and chamber 164 is carried counterclockwise around by rotor A.

Compression

From reviewing FIGURES 11 to 14, it will be seen that as rotors A and B rotate, air in chamber 154a, defined by rotor lobes B_1 and B_5 and originating

from primary air intake 150, (FIGURES 10, 11) and air in chamber 164, defined by rotor lobes A_2 and A_3 and originating from secondary air intake 160, (FIGURES 10 and 11) merge into a single volume (FIGURES 12, 13) designated as 176. The volume in merged chamber 176 is compressed by lobe A_3 of rotor A in cooperation with lobes B_1, B_5 of rotor B to provide maximum compression (FIGURE 14). During the above process, rotor C continues to rotate, carrying positive air charge volume 154b, as shown through FIGURES 11 to 14.

<u>Combustion</u>

At or near the point of maximum compression as seen in FIGURE 14, a source of ignition schematically designated as spark plug 182 in lobe A_3 of rotor A, ignites the compressed air/fuel mixture in merged chamber 176, causing the mixture to burn and the gases to heat up, thus expanding and increasing pressure within the chamber 176 significantly. This increased pressure causes the rotors to continue to turn, rotor A counterclockwise and rotor B clockwise providing a power arc. As rotors A and B rotate from FIGURE 14 to FIGURE 16, the combustion gases in previously merged air/fuel chamber 176, now combustion chamber 176, breaks into two combustion chambers 178a and 178b. In other words, the combustion volume 176 splits into two combustion volumes 178a, defined between rotor lobes A_2, A_3 and 178b, defined between rotor lobes B_1 and B_5 (FIGURE 17). Each chamber 178a and 178b is carried around by the respective rotors A and B, both containing combustion gases under pressure.

<u>Exhaust</u>

Combustion gases in chamber 178a are exhausted from secondary port 162 (FIGURE 18) and those in chamber 178b are exhausted from primary exhaust port 152. Exhaust gases in chamber 178a begin to exhaust through secondary exhaust port 162 prior to gases in chamber 178b exhausting through primary exhaust port 152 (FIGURE 18). As gases in chamber 178a are exhausted from secondary port 162, air entering port 160 scavenges the chamber to aid in the more complete exhausting of combustion gases (FIGURE 19).

Gases in chamber 178b are exhausted through primary exhaust port

152 but aided by the positive air charge air carried around in chamber 154b by rotor C and by the fact that chambers 178b and 154b are merging through cooperation of lobes B_1 and B_5 with lobe C_2. Substantially all combustion gases carried by rotor B are forced out through port 152.

With the additional rotor C, more efficient and effective scavenging of combustion gases from rotor B is provided as well as a more positive intake of air through port 150. Any unburnt fuel in chamber 178b is met by the charge of fresh air in chamber 154b which aids in burning of any unburnt fuel and therefore reduction in unburnt fuel emissions from ports 152.

Variations and Alternatives

FIGURE 4 shows the power take-off to be associated with rotor B (104). Rotor B turns the slowest and gives the better torque of the three shafts. Further, its location as illustrated, provides symmetry and ease in mounting the engine. Nevertheless, power can be taken from the shafts of either rotor A or rotor C.

FIGURE 3 shows fuel injector 170 located at a particular location in the side wall of engine block 134. However, it should be noted that the fuel injector can be provided at any location in the side wall between the arrows x-y shown in FIGURE 3. Further, FIGURE 20 schematically illustrates in section a lobe 210 of a rotor having spark plug 212 and fuel injector 214 supplied by fuel through conduit 216, appropriately sealing associated with the rotor and a fuel supply, not shown. When lobe 210 is located in conjunction with another rotor at substantially maximum compression, cavity 220 defines the appropriate space to provide the compression ratio desired of the engine (e.g. 10:1). It is also noted that fuel injection, as an alternative, could be provided through the lobes of rotor B.

The preferred embodiment herein has shown rotors A, B and C with 3, 5 and 3 lobes respectively. Notwithstanding the preferred embodiment herein showing this relationship, rotors A, B and C can be configured with different numbers of lobes, such as, 3, 4 and 2 respectively. The gears which control the rotors must be appropriately sized to provide for such variations. Such an

embodiment is more particularly illustrated schematically in FIGURE 21. Rotors A_1, B_1 and C_1 in FIGURE 21 have 3, 4 and 2 lobes respectively. Rotors A_1, B_1 and C_1 are housed in block section 234 with intake ports 250, exhaust port 252, intake 260 and exhaust port 262, similar to 150, 152, 160, 162 respectively of FIGURE 3. Synchronizing gears 270, 272 control the cooperative meshing of rotors A_1 and B_1, whereas synchronizing gears 174, 276 control the cooperative meshing of rotors B_1 and C_1. It will be appreciated that rotor B_1 carries two separate synchronizing gears 272 and 276. In this embodiment, it will be appreciated that there is more air carried around by rotor C_1 for mixing with combustion/exhaust gases than in the embodiment of FIGURE 3.

One of the advantages of my design over the prior art is the effective four cycle operation of this engine. The prior art would have required additional components to provide scavenging and fresh air supply functions. Since both of those functions use the same porting on the prior art, some overlap would necessarily occur. This is a natural by-product of engines of the "two-stroke" design where the first stroke is "intake/compression" and the second is "combustion/exhaust". This type of engine will re-ingest a portion of the exhaust and waste a portion of the intake fuel/air. This reduces efficiency and causes excessive emissions of unburned hydrocarbons.

My new design has a four-cycle operation, where each part of the cycle (intake, compression, combustion, exhaust) is physically located away from the other operations. As well, each of the cycles has no overlap with any other cycle. This advantage over two cycle designs eliminates the possibility of re-ingesting exhaust gases, or wasting fuel/air through the exhaust port. In general, a more fuel efficient clean burning engine is possible with this new design.

An additional feature of the new engine is the ability to further reduce emissions without complicated add-on technology such as a catalytic converter. This is accomplished with the third rotor "C". As the primary air inlet stream enters the engine through intake port 150, it is divided into two portions by rotors B and C. The volume in rotor B is used for the combustion process, whereas the volume defined in rotor C is carried around to the exhaust port 152 (or 252). This volume of fresh air is then added to the exhaust being carried by

rotor B. The effect of this process is that any unburned hydrocarbons in the exhaust now have an excess supply of oxygen in the air to complete the combustion process. The dilution effect of the fresh air will also serve to lower the temperature of the exhaust and so minimize the formation of other pollutants through chemical dissociation (which occurs most at very high temperatures with excess oxygen).

I Claim:

1. In a rotary internal combustion engine of the type having first and second intermeshing lobed rotors housed within an engine block, said first and second rotors each having a plurality of lobes and grooves, each lobe of the first rotor adapted to intermesh with a groove of the second rotor, said intermeshing of the rotor lobes and grooves being controlled by intermeshing first and second gears connected respectively to each rotor and wherein said engine has a first air intake port and a first exhaust port in communication with said first rotor, a second air intake port and second exhaust port in communication with said second rotor, each rotor being adapted to carry an air charge between its respective associated intake port and a point of combustion and exhaust gases between said point of combustion to its respectively associated exhaust port, means for injecting fuel serially into air charges in said engine and ignition means for igniting compressed air/fuel charges for combustion;

the improvement comprising a third lobed rotor, said third rotor having a plurality of lobes and grooves and being mounted whereby the lobes and grooves thereof intermesh with lobes and grooves of said second rotor in a gear controlled relationship, said third rotor cooperating with said second rotor adjacent said first air intake port and said first exhaust port whereby a positive air charge is formed and carried by said second rotor to combustion and a positive air charge is formed and carried by said third rotor to adjacent said first exhaust port and into communication with exhaust gases carried by said second rotor.

2. The engine of claim 1 wherein said third rotor is configured similar to said first rotor and said third rotor is connected to a third gear which intermeshes with said second gear.

3. The engine of claim 2 wherein said first and third rotors have three lobes and three intermediate grooves and said second rotor has five lobes and five intermediate grooves.

4. The engine of claim 1 wherein said first rotor has three lobes and three intermediate grooves, said second rotor has four lobes and four intermediate grooves and said third rotor has two lobes and two intermediate grooves, intermeshing between lobes and rotors between said first and second rotors being controlled by one set of gears and the intermeshing between lobes and grooves between said second and third rotors being controlled by a second set of gears.

5. The engine of claim 3 wherein said fuel injection means injects fuel into an air charge carried by said second rotor.

6. The engine of claim 3 wherein said fuel injection means injects fuel into an air charge carried by said first rotor.

7. The engine of claim 3 wherein said fuel injection means injects fuel into an air charge formed from combining individual air charges carried by said first and second rotor.

8. The engine of claim 3 wherein each of the lobes of said first rotor includes fuel injection means.

9. The engine of claim 4 or 5, wherein each of the lobes of said first rotor includes an ignition means.

10. The engine of claim 6 wherein each of the lobes of said first rotor includes an ignition means.

11. The engine of claim 7, wherein each of the lobes of said first rotor includes an ignition means.

12. The engine of claim 8, wherein each of the lobes of said first rotor includes an ignition means.

CA 02256888 1998-12-21

ROTARY ENGINE

Abstract of the Disclosure

Disclosed is a three rotor engine of the intermeshing lobe and groove type wherein the rotors are transversely aligned and sealingly cooperate with a casing to provide a power rotor, an abutment rotor and a scavenging rotor. The scavenging rotor provides for a positive formation of an air which forces exhaust gases out a primary exhaust port and also aids in air intake through a primary air intake port by expanding the chamber defined between adjacent lobes which provides for the formation of a positive air charge in the chamber for use in the combustion engine. The scavenging rotor helps in reducing unburnt fuel emissions in the exhaust as it provides a charge of fresh air into the exhaust from the abutment or middle rotor to allow complete combustion of any fuel still remaining unburnt in such exhaust.

Fig.1 (PRIOR ART)

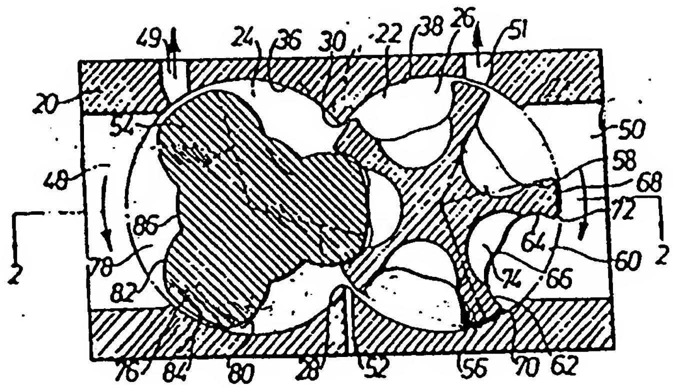
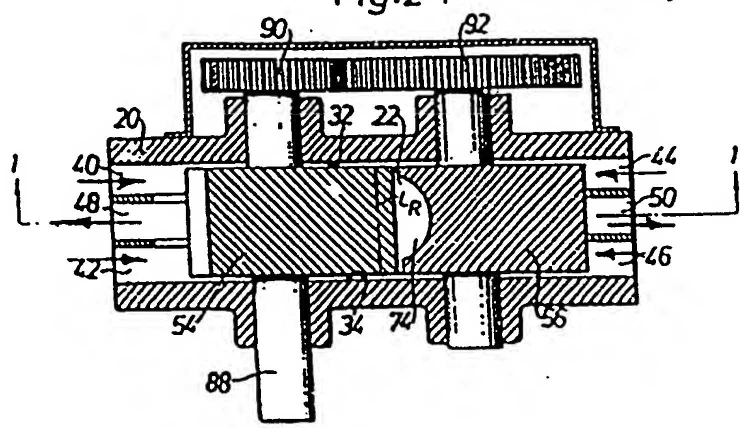


Fig.2 (PRIOR ART)



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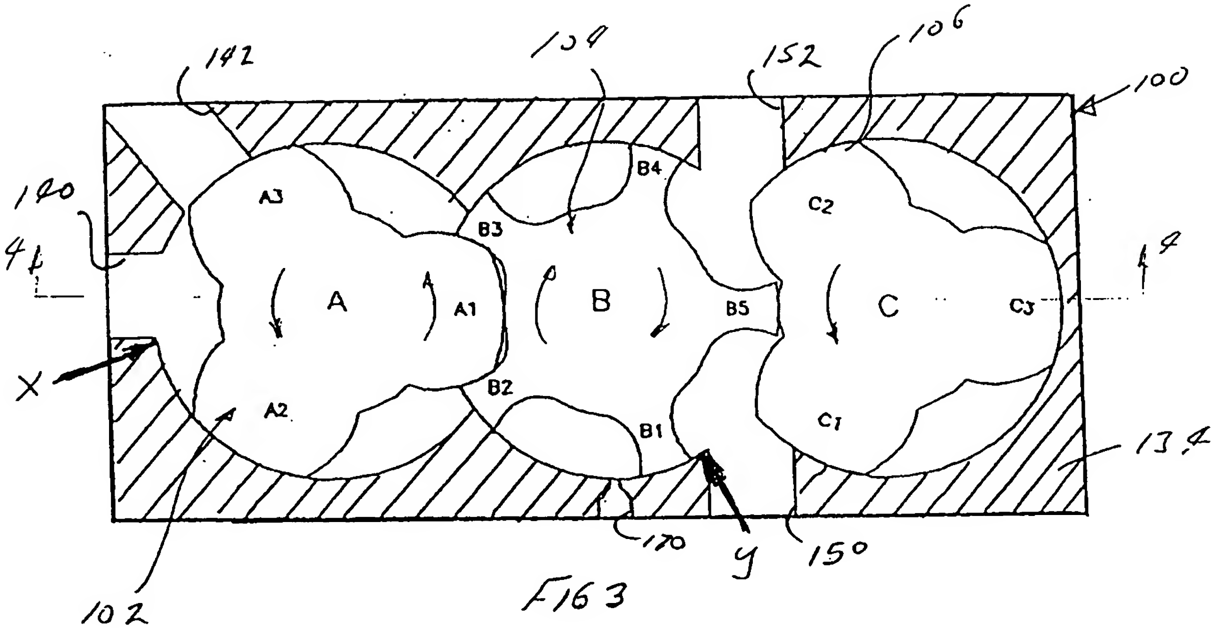

FIG 3

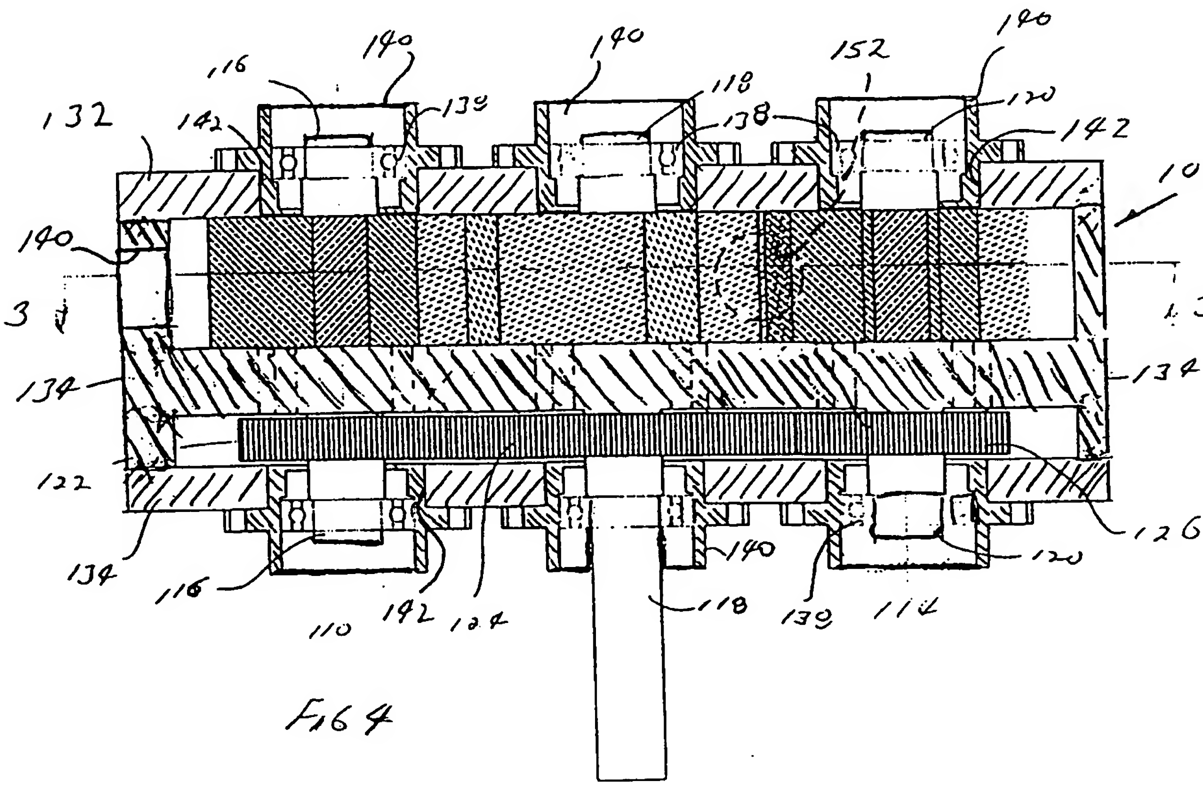

FIG 4

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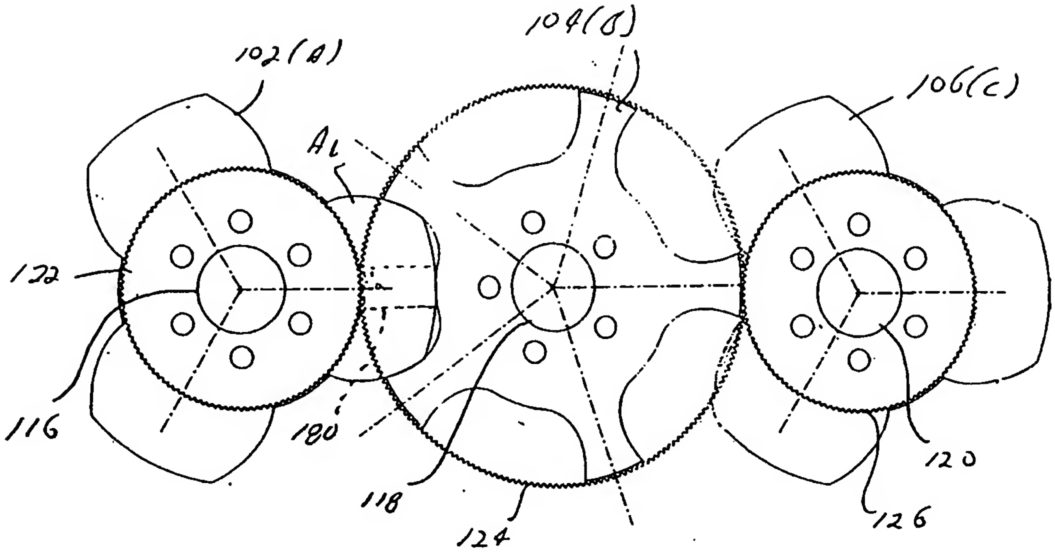

FIG 5

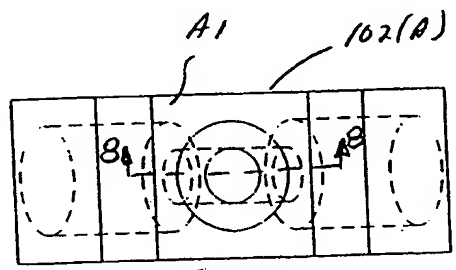

FIG 7

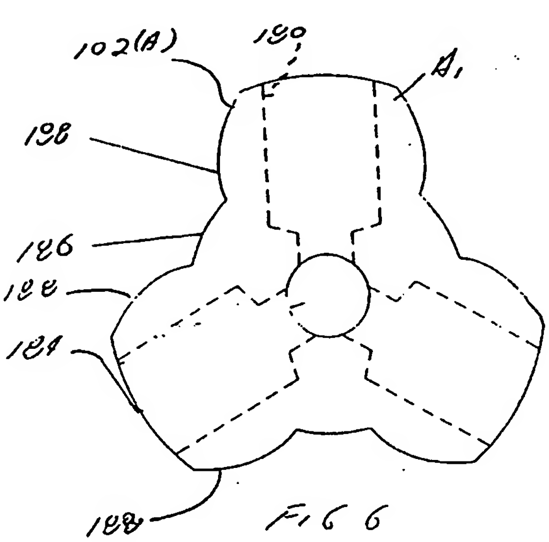

FIG 6

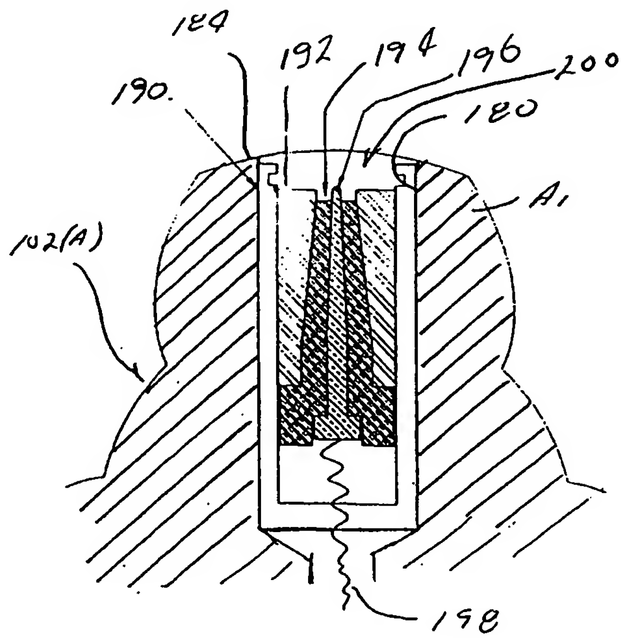

FIG 8

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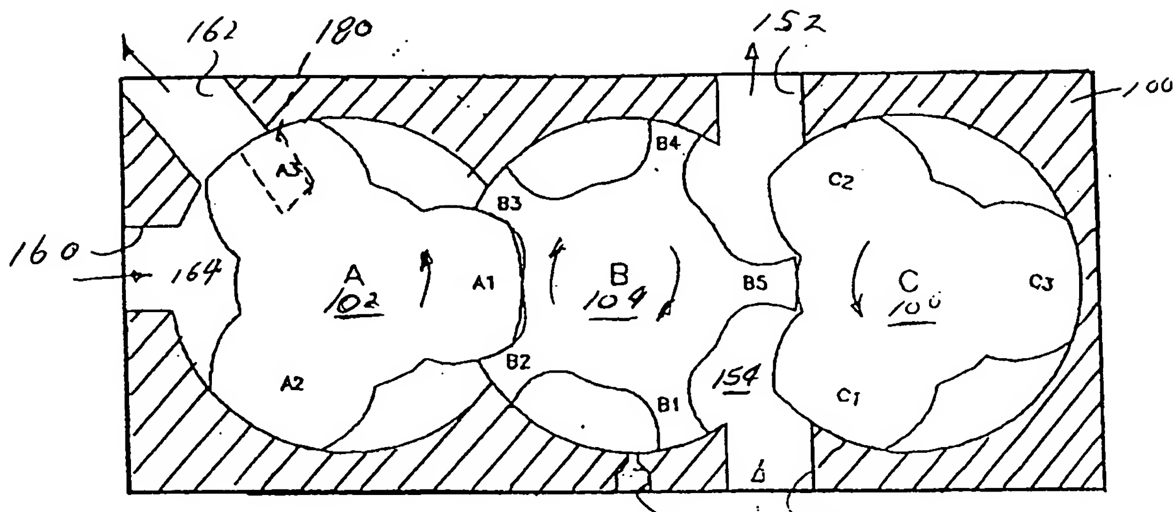

FIG 9

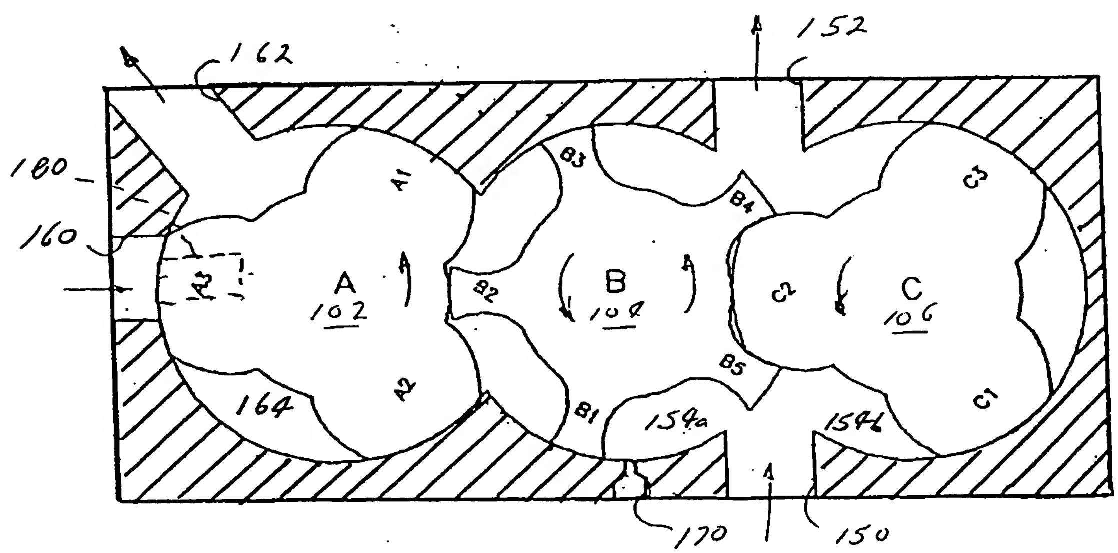

FIG 10

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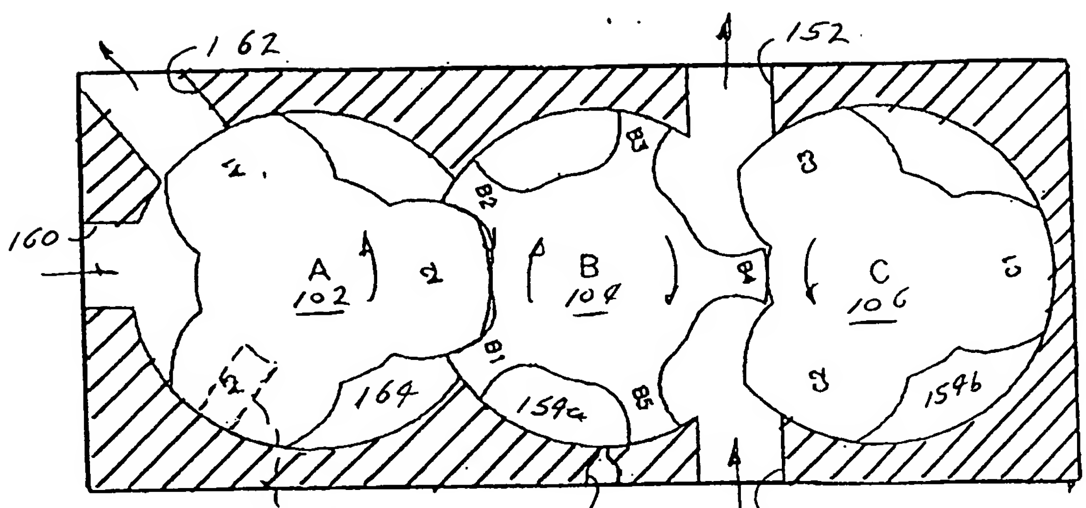

FIG 11

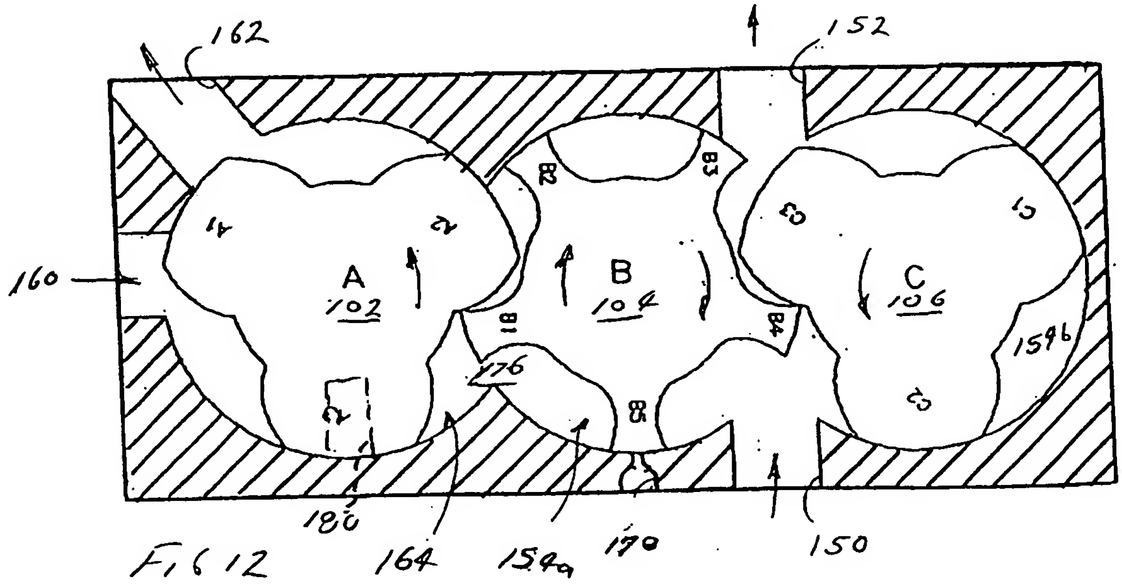

FIG 12

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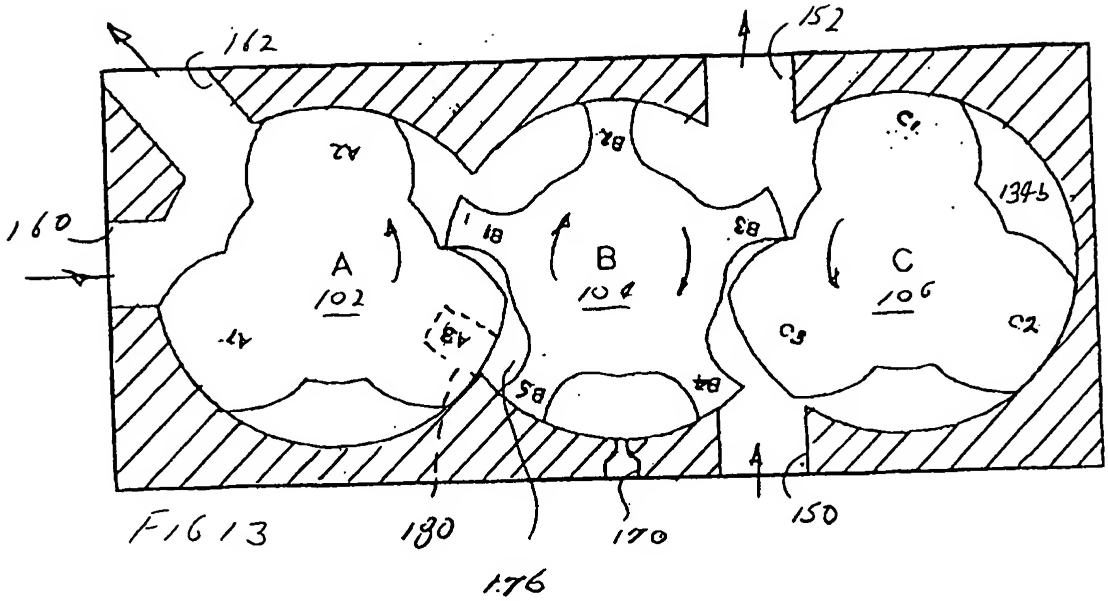

FIG 13

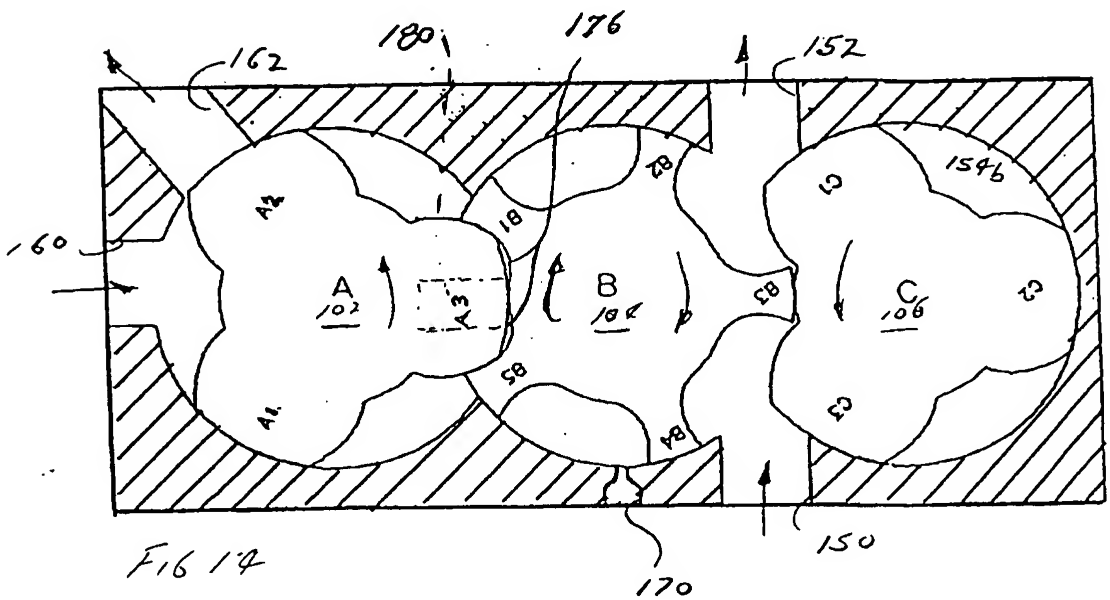

FIG 14

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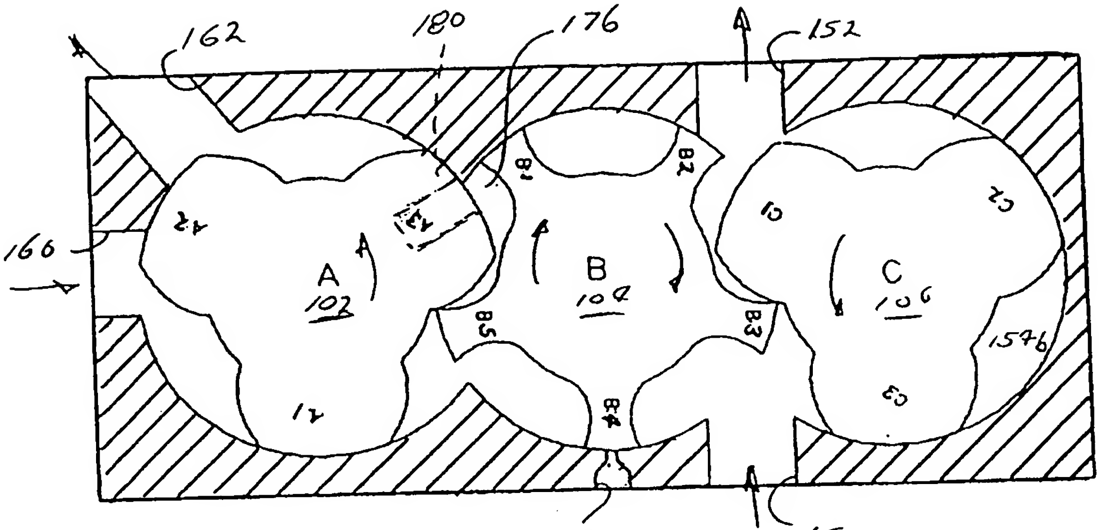

FIG 15

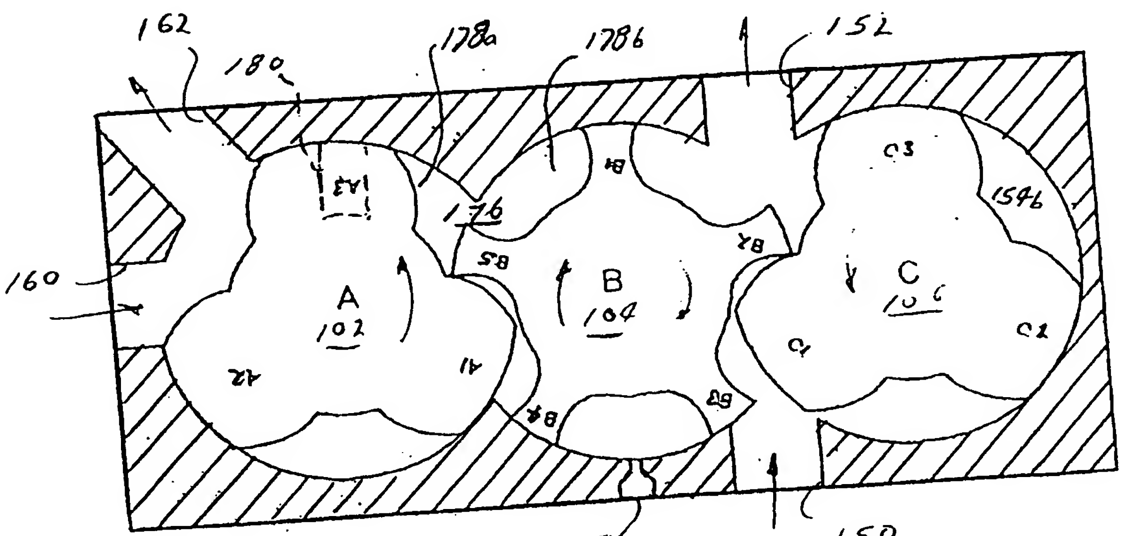

FIG 16

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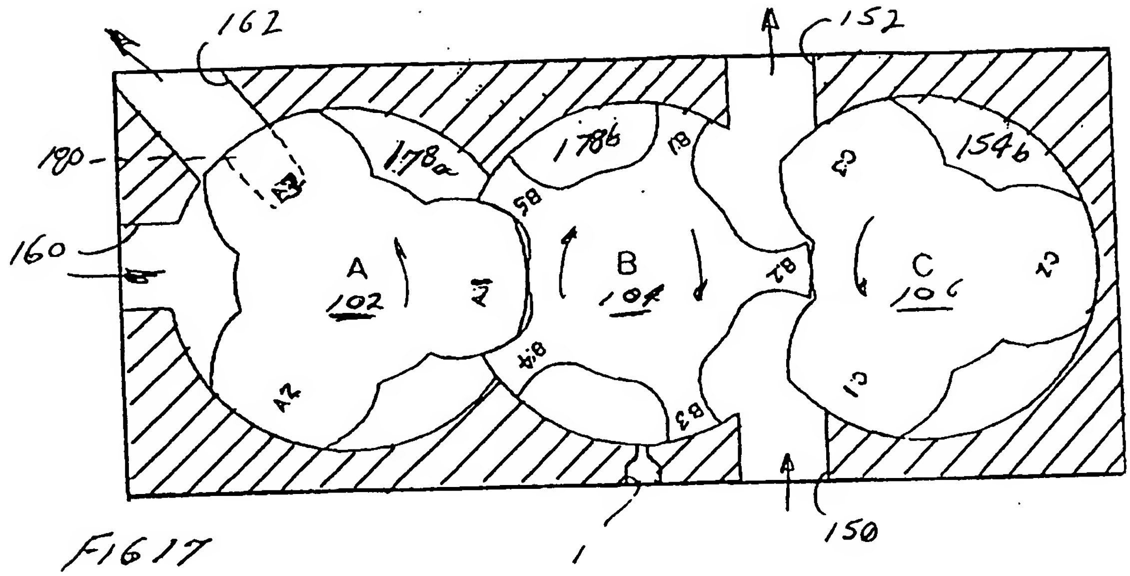

FIG 17

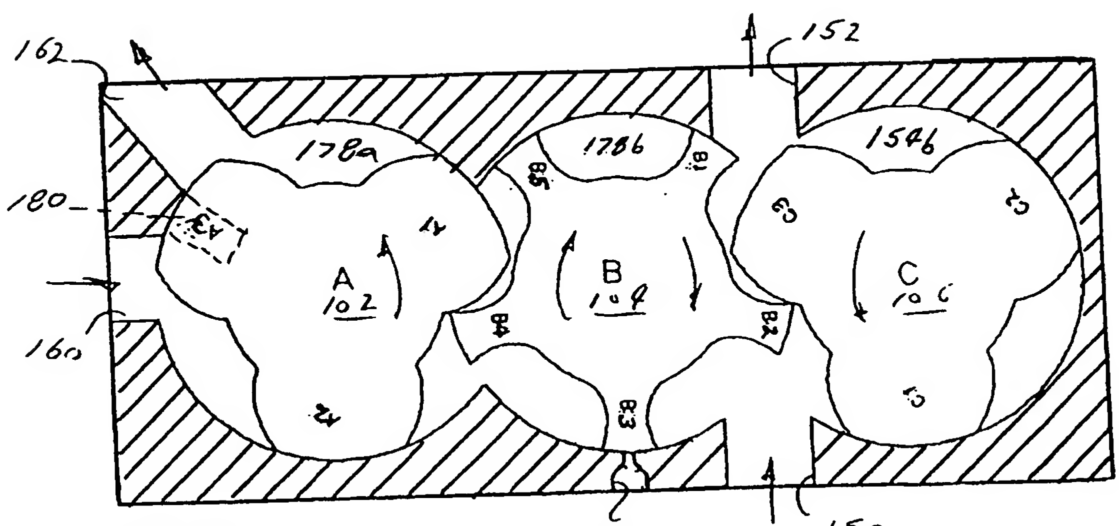

FIG.18

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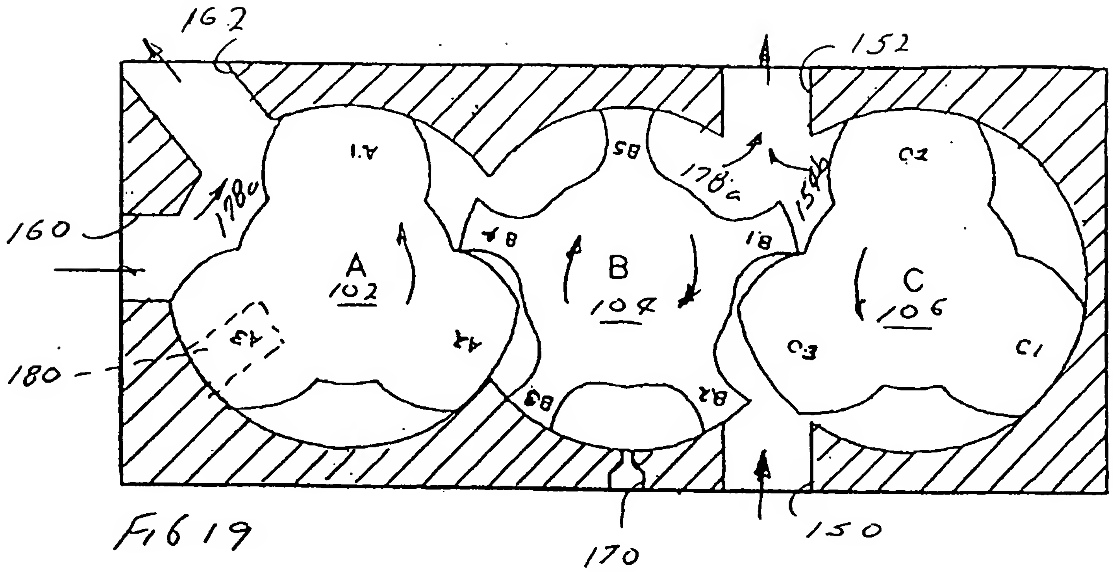


FIG 19

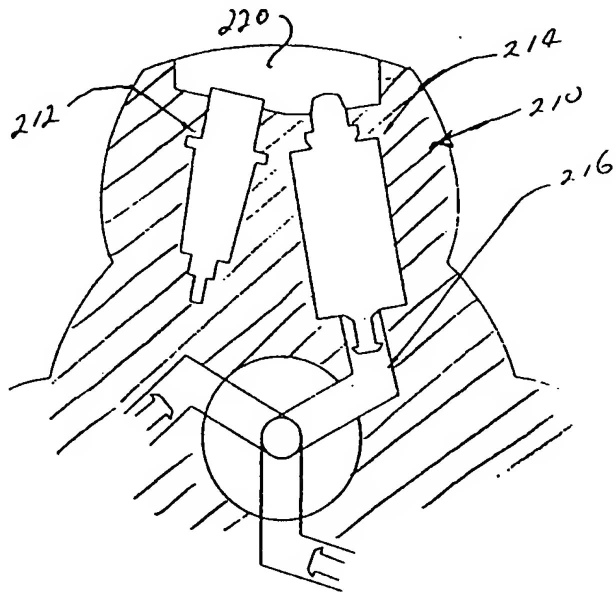
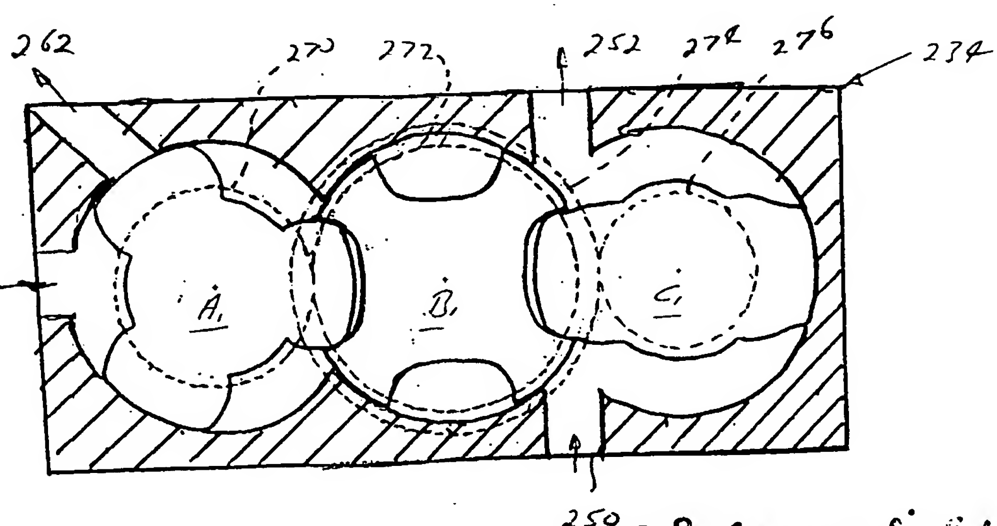


FIG 20

FIG 21



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